



Guide to the
Lunar CRater Observation and Sensing Satellite (LCROSS) Project Collection, 2007-2010
AFS8000.5-LCROSS

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NASA Ames Research Center

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Descriptive Summary

Title:

Lunar CRater Observation and Sensing Satellite (LCROSS) Project Collection, 2007-2010

Collection Number:

AFS8000.5-LCROSS

Creator:

Ames Research Center

Dates:

Inclusive: 2007-2010

Extent:

1,145 digital objects (approx. 40.9 gigabytes) and 7.6 cubic feet of analog material

Repository:

NASA Ames History Office
Moffett Field, California 94035

Abstract:

This collection of Lunar CRater Observation and Sensing Satellite (LCROSS) records, accumulated by various team members, primarily contains material related to the mission's outreach efforts. Included are digital photographs, fact sheets, booklets, technical papers, briefings, presentations, video footage, social media campaign records, awards, posters, ephemera, artifacts, and memorabilia.

Administrative Information

Access:

Collection is open for research. Access to one item in the collection is subject to national export restrictions.

Publication Rights:

Copyright does not apply to United States government records. For non-governmental material, the researcher must contact the original creator.

Preferred Citation:

Expanded:

NASA Ames History Office, NASA Ames Research Center. Moffett Field, California.
AFS8000.5-LCROSS, Lunar CRater Observation and Sensing Satellite (LCROSS)
Project Collection, 2007-2010, [Container number] : [Folder number]. [Identification of
item]. [Date, if available].

Abbreviated:

NASA ARC. AFS8000.5-LCROSS, [Container number] : [Folder number]. [Identification of item]. [Date, if available].

Acquisition Information:

Transferred from LCROSS team members Stephan F. Ord on March 8, 2011; Kimberly Ennico Smith on March 14, 2011; Khaled F. Galal on March 23, 2011; Daniel Andrews on April 18 and 21, 2011 and May 23, 2011; and Robert D. Barber on June 9, 2011.

Accruals:

An oversize banner transferred by Dan Andrews on July 23, 2013 was added to Series III (Acq. 016-2013).

Administrative History

On June 18, 2009, NASA launched the Lunar CRater Observation and Sensing Satellite (LCROSS, shepherding spacecraft) as a secondary payload to the Lunar Reconnaissance Orbiter (LRO), from Cape Canaveral atop an Atlas V 401 rocket on a mission to study Earth's moon. LCROSS was designed to confirm the presence and nature of water ice on the moon, and to study the composition of lunar regolith by using the launch vehicle's upper stage as a kinetic impactor and its shepherding spacecraft as a data collector. The impact would dislodge lunar material at the bottom of permanently shadowed crater near the moon's south pole and elevate it high into the sunlight, thus enabling the instruments aboard the spacecraft to record its characteristics. The main task of the LRO mission, which is still active, was to map the moon and characterize future landing sites. Both missions achieved their primary objectives. LCROSS detected water in the moon's Cabeus crater, and LRO returned nearly 200 terabytes of images and high-resolution maps of the lunar surface, and continues to transmit altimeter measurements back to Earth.

LCROSS separated from LRO shortly after launch, carrying the spent upper stage portion of the Centaur rocket with it, and proceeded to shepherd the rocket tank to the impact site. The trajectory consisted of a lunar flyby on June 23, 2009, followed by highly elliptical polar Earth orbits (Lunar Gravity Assist Lunar Return Orbits), designed to give the craft a high angle of impact and sufficient speed to maximize the amount of material kicked up during impact. The plan while in transit was to allow the fuel remaining in the rocket to dissipate and to turn the sides of the tank toward the sun in order to bake out residual water. The flight proceeded smoothly until August 22, 2009, when the operations team detected an alarming, mission-threatening anomaly as it prepared to orient the cold side of the tank toward the sun. Preceding this maneuver, during a planned break in communications with the spacecraft, a systems malfunction had caused the thrusters to fire almost continuously and burn a sizeable amount of propellant. However, the team resolved the spacecraft emergency in time to guide LCROSS to the impact site without running out of fuel. On October 9, 2009, the LCROSS shepherding spacecraft separated from the Centaur and sent the rocket tank hurtling toward the bottom of the Cabeus crater at a speed of about two kilometers a second. It then performed a braking maneuver to create a four-minute distance, positioned its instruments toward the impact site, and followed the Centaur down to strike the moon in its turn. The first

impact dislodged a large plume of debris, dust, and vapor (approximately 250-350 metric tons), which was measured and photographed by the shepherding spacecraft before that spacecraft hit the surface minutes later. This final stage of the mission was timed so that LRO, orbiting high above the crash site, would be in position to collect data from both impact events.

The data returned from the instruments aboard LCROSS and LRO showed that the debris plume contained pure water ice grains as well as volatiles, such as methane, ammonia, hydrogen gas, carbon dioxide and carbon monoxide, and some light metals, such as sodium and mercury. This detection of water on the moon definitively confirmed what the scientific community had already suspected based on data obtained from three earlier lunar missions that remotely detected the chemical signatures of water in the moon's polar regions: Clementine (Naval Research Laboratory, launched 1994), Lunar Prospector (NASA Ames Research Center, launched 1998), and Chandrayaan-1 (Indian Space Research Organization, launched 2008).

Mission Development and Management

Northrop Grumman, located in Redondo Beach, California, designed and built the LCROSS spacecraft bus with oversight from the team at NASA Ames Research Center. In order to fit LCROSS into the launch vehicle as a secondary payload to LRO, an Evolved Expendable Launch Vehicle Secondary Payload Adaptor, or ESPA ring, served as the main structure of the spacecraft. Designers placed the fuel tank inside the ring and positioned the science instruments, solar array, command and control systems, communications devices, antennas, and batteries around the outside of the ring. The craft carried a science payload of nine instruments designed and developed by NASA Ames for observing the impact and the characteristics of the resulting ejecta cloud: five cameras (one visible, two near infrared, and two mid-infrared), one total luminance photometer, one visible spectrometer, and two near infrared spectrometers.

On April 10, 2006 NASA's Exploration Systems Mission Directorate selected the NASA Ames proposal for LCROSS to lift off as a secondary payload to the LRO. LCROSS had to remain within a budget of 79 million dollars, weigh less than 1,000 kilograms, and be completed in time for the LRO launch scheduled just 31 months following the selection date. To meet these requirements, the designers pursued a non-traditional approach, creatively employing various management measures and incorporating low-cost components. For example, they assembled a humble but fully capable control room from a series of networked personal computers patched into the secure local network at NASA Ames. The spacecraft incorporated durable, commercially-available, "off-the-shelf" materials such as the visible camera and other scientific instruments, and existing flight-qualified hardware, such as the ESPA ring, rather than costly, time- and resource-consuming custom-made items. The Centaur was repurposed for use as the kinetic impactor, thus maximizing the mass available to the working payload. Ultimately, the spacecraft was completed and approved on time, at a total mission cost of 79 million dollars.

The mission was managed from NASA Ames Research Center in Moffett Field, California, under the direction of Project Manager Daniel R. Andrews of the Office of the Director of

Programs and Projects, Project Management Division (Code PX). NASA Ames Principal Investigator Anthony Colaprete led the science investigations (Office of the Director of Science, Space Science and Astrobiology Division, Planetary Systems Branch, Code SST). Northrop Grumman, Goddard Space Flight Center, Kennedy Space Center, and the Deep Space Network provided operational support.

Social Media Outreach

In addition to the usual channels such as traditional Web sites, printed publications, and broadcast media, the LCROSS mission team experimented with disseminating information to the public in real time through two social media platforms, Facebook and Twitter. Accounts were set up in June 2008 and maintained throughout the entire mission by Payload Scientist Kim Ennico Smith and Observation Coordinator and Co-Investigator Jennifer Heldmann, with support from other team members and NASA Ames public affairs officers. The Twitter feed, which was presented from the point of view of the spacecraft, was terminated after the impact event, followed by the Facebook page a few months later. On average, Twitter was updated about twice a day and Facebook twice a week, with heavier messaging during the launch, flyby, and impact events. Thousands of individuals from all over the world signed on as Facebook "fans" and Twitter "followers." Before the spacecraft launch, each outlet had about 2,000 followers, whose numbers climbed during the launch phase, then again during impact phase. After impact, there were over 11,000 Facebook fans and approximately 13,300 Twitter followers.

Sources Consulted

- Andrews, Daniel. *Managing the Bad Day*. Ask Magazine. Issue 44, Fall 2011.
- Indian Space Research Organization. *Chandrayaan-1*. Retrieved January 12, 2012 from www.isro.org/chandrayaan/
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Scope and Content

The Lunar CRater Observation and Sensing Satellite (LCROSS) Project Collection (7.6 cubic feet and 1,145 digital objects totaling approximately 40.9 gigabytes) contains records and artifacts accumulated by various LCROSS Team members, including Project Control Manager, Stephan Ord, Payload Scientist Kimberly Ennico Smith, and Project Manager Daniel Andrews. The bulk of the material is in electronic format and documents the team's outreach efforts to inform, educate, and engage the general public and scientific community. Other records were generated for internal use in the course of planning and executing the mission, for inspiring the team, and for commemorating milestones with family and friends. Included are some informational materials produced outside of Ames about the mission, as well as honors and awards bestowed on the team by NASA and other institutions.

Series I contains a full set of the records that were accumulated by the project office and cleared for public release. Included are digital photographs, fact sheets, booklets, technical papers, briefings, presentations, news releases, magazine articles, data samples, spacecraft animations, video footage of the spacecraft assembly and an environmental test, broadcasts featuring the mission, toys, and games. **Series II** documents the social media campaign on Facebook and Twitter with reports, statistics, and archived material. **Series III** consists of artifacts and oversized material in the form of awards, posters, memorabilia, and ephemeral items. **Series IV** includes images, operational material, and video collected by various individual team members from Ames and other institutions.

System of Arrangement

This collection is arranged in four series:

- I. Outreach and Educational Material for Public Release
- II. Social Media Campaign Records
- III. Awards, Memorabilia, and Ephemera
- IV. Miscellaneous Material Accumulated by LCROSS Team Members

Series are organized by function according to donors, with contents further arranged alphabetically and according to format (analog textual materials, digital materials, artifacts, and oversized material). Series IV records subject to national export restrictions are boxed separately. "Born digital" records were mainly kept in their original order, with the exception of a few slight shifts to avoid redundancies. Loose analog versions of digital files were physically placed with files for the corresponding digital records, in accordance with the digital file structure.

Though the bulk of this collection is in digital form, it is represented as being physically arranged into boxes and folders. This scheme was chosen to best accommodate access to the blend of digital and physical materials. All folders bearing "Digital" in the title contain copies of the full file directories, while all folders marked "Analog" contain any physical items the team produced from the digital files, as well as selected copies of some of the files printed out by the archivist. Researcher access is not limited to analog records.

Series Descriptions

Series I: Outreach and Educational Material for Public Release (16 folders of textual materials and 990 digital items totaling approximately 39.5 gigabytes).

This series contains records cleared for public release that were accumulated by Project Control Manager Stephan Ord. The bulk of this series is electronic ("born digital"), as submitted, and falls into ten categories, representing the top-level file directory structure.

- The *Booklets* and *Fact Sheets* categories include informational material about the mission, spacecraft, launch architecture, and the moon that was generated for the general public by NASA, Northrop Grumman, and United Launch Alliance. This part of the collection consists of a twenty-page informational booklet along with single-page handouts.
- The *Images* category contains photographic material and illustrations generated by the Public Affairs Office. This part of the collection consists of directories holding sets of individual image files, with most sets grouped into a PowerPoint presentation. Subjects represented include the mission teams; the spacecraft, launch architecture and instrument components; teams assembling the spacecraft in clean rooms; transportation of the spacecraft to Cape Canaveral; preparation for and execution of the launch; the project team in the mission operations control room at NASA Ames; and mission staff, Ames employees, and the public working and reveling on the night LCROSS impacted the moon.

- The ***Kids' Stuff*** category is comprised of material designed to appeal to children. This part of the collection consists of an LCROSS coloring book, a video game, and a punch-out-and-fold paper model kit.
- The ***Papers*** category contains documents related to technical papers delivered before and after the mission. Topics include mission project management, transportation and use of a Centaur rocket in space, communications, flight operations, flight team development, ground system development, trajectory design and orbit determination, and mission design. Authors include Richard Alena, Daniel Andrews, Robert Barber, John Bresina, Anthony Colaprete, D. Steven Cooley, Dean Dailey, Eric Drucker, Howard Eller, Darin Foreman, Brian Kennedy, Amy Lo, Louie T. Luzod, Tim McElrath, Bernard Morgowicz, James Munger, Matthew D'Ortenzio, Khaled (Ken) Galal, Rusty Hunt, Scott Sawyer, Mark Shirley, James Strong, Paul Tompkins, Nho Vo, and James Wehner. The bulk of the material is technical papers and associated PowerPoint presentations prepared for American Institute of Aeronautics and Astronautics technical conferences in 2010.
- The ***Posters*** category contains two posters produced by NASA, one featuring LCROSS and the other featuring both LCROSS and LRO.
- The ***Presentations*** category contains a few mission briefings and overviews dated from 2007-2010, and NASA Administrator Charles F. Bolden's remarks at the 2009 Wernher von Braun Memorial Symposium in Huntsville, Alabama.
- The ***Statements and Articles*** category includes NASA and Northrop Grumman news releases, and article content for *Space Times* and *Aerospace Now* dated from 2008-2010.
- The ***Videos and Music*** category contains video footage, computer-generated animations, and television coverage describing or depicting the mission, including programs produced by NASA, Northrop Grumman, the Public Broadcasting Service of the United States (NOVA, Science Channel) and Northern California (KQED Quest), CBS News (60 Minutes), and the British Broadcasting Corporation. Of note are the music and video files of the LCROSS theme song entitled "Water on the Moon," which was composed and performed by Deputy Project Manager, John Marmie.

Document and still image formats: Microsoft Word (DOC, DOCX), Joint Photographic Experts Group (JPEG), Microsoft PowerPoint (PPT, PPTX), Portable Document Format (PDF), Portable Network Graphics (PNG) Stereolithography (STL), Tagged Image File Format (TIFF), Extensible Markup Language (XML).

Audio and video formats: Audio Video Interleave (AVI), Backup (BUP), Flash Video (FLV), Information (IFO), Motion Picture Editors Guild Video (MPEG-4, M4V, MPG), QuickTime Movie (QT, MOV), Unix Executable, USR, VirtualDub Video Filter (VDF), DVD Video Object (VOB), Windows Wave audio (WAV), Windows Media Audio (WMA), Windows Media Video (WMV).

Series II: Social Media Campaign Records (8 folders of textual materials and 66 digital items totaling approximately 32 megabytes).

This series contains records accumulated by Payload Scientist Kimberly Ennico Smith. The bulk of this series is in electronic form ("born digital"), as submitted. The records here mainly document the LCROSS mission's experimentation with social media outreach on Twitter and Facebook, from spring 2008 until a few months after the mission ended in October 2009. Contents include project and statistical reports about LCROSS social media efforts, screen captures of Facebook and Twitter postings by the LCROSS team, Facebook fan comments, and Twitter posts, or "tweets."

Formats: Microsoft Word 1997 and 2008 (DOC, DOCX), Portable Document Format (PDF), Plain Text Document (TXT), Joint Photographic Experts Group image (JPEG), Portable Network Graphics (PNG).

Series III: Awards, Memorabilia, and Ephemera (14 folders, artifacts).

This series contains artifacts and oversized materials accumulated by Project Manager Daniel Andrews, Mission Design Lead Khaled (Ken) F. Galal, and Project Systems Engineer Robert D. Barber. Included is an assortment of LCROSS memorabilia, ephemera, oversized material, and awards. These last were bestowed on the team by NASA, The National Space Society, Popular Mechanics Magazine, and the Space Foundation. Ephemeral material includes mission decals, informational cards, a bookmark, and other items, such as a clear plastic water bottle with "LCROSS/Northrop Grumman" and "Got Water?" printed on the sides. Memorabilia include mission patches and pins, and a bottle of "Craterade" LCROSS Impact Ale, one of a few select batches of LCROSS beer brewed by Contracting Officer Jeffrey S. Brown. Of note is a copy of a bound, softcover book entitled "LCROSS Memories," compiled by Project Manager Daniel Andrews and distributed to the team. The "memory book," as it's called, is a scrapbook that tells the story of the LCROSS mission and provides an intimate glimpse into the people who worked on it. Inside are copies of official documents such as memos and other correspondence, organization charts, schedules, presentations, overviews, and professional photographs, as well as unofficial material such as snapshots of team members with their families and quotations of different messages posted on the whiteboard during the project. Oversized material in this series is comprised of banners signed by the team and their families, a project team photograph, and posters featuring the LCROSS spacecraft, scientific operations, and the launch vehicle.

Series IV: Miscellaneous Material Accumulated by LCROSS Team Members (7 folders of textual materials and 89 digital items totaling approximately 1.4 gigabytes).

This series contains miscellaneous material related to LCROSS that was accumulated by various team members from NASA Ames Research Center, NASA Marshall Space Flight Center, the Jet Propulsion Laboratory, and Northrop Grumman. Included are a launch console handbook, snapshots and mission images that individuals thought were memorable, screen shots of Northrop Grumman Lead Flight Software Engineer Emory Stagmer's

Facebook album entitled "LCROSS launch campaign and on-going operations," and video footage of two Spacevidcast shows featuring LCROSS.

Formats: Flash Video (FLV), Motion Picture Editors Guild Video (MPEG-4, M4V, MPG), QuickTime Movie (QT, MOV), Graphics Interchange Format (GIF), Joint Photographic Experts Group (JPEG), and Portable Network Graphics (PNG).

Indexing Terms

The following terms may be used to index this collection.

Corporate Name

Ames Research Center

Northrop Grumman Corporation. Aerospace Systems

Subjects

Lunar CRater Observation and Sensing Satellite (Spacecraft)

Lunar exploration

Moon--Exploration--20th century.

Water--Moon.

Separated Material

Some duplicate digital items were removed. When identical content appeared in both compressed and uncompressed directories, the former was removed and the latter retained.

Related Material

AFS8000.5-LCROSS supplemental finding aid: File directory structure

AFS8000.5-LCROSS supplemental finding aid: Catalog records, artifacts

AFS8000.5-LP: Lunar Prospector Project Records, 1995-1998

AFS1070.8A: Archives Reference Collection

Container List

Series I: Outreach and Educational Material for Public Release

Box	Folder	Folder Title
1	1	Booklets, Digital (40 files)
	2	Booklets, Analog
	3	Fact Sheets, Digital (4 files)
	4	Fact Sheets, Analog
	5	Images, Digital (563 files)
	6	Kids' Stuff, Digital (39 files)
	7	Kids' Stuff, Analog
	8	Mission Data and Tools, Digital (21 files)
	9	Mission Data and Tools, Analog
	10	Papers, Digital (42 files)
	11	Papers, Analog
	12	Posters, Digital (2 files) See also oversized material in Series III
	13	Presentations, Digital (10 files)
	14	Presentations, Analog
	15	Statements and Articles, Digital (23 files)
	16	Videos and music, Digital (246 files)

Series II: Social Media Campaign Records

Box	Folder	Folder Title
1	17	LCROSS: Twitter, Facebook, Digital (39 files)
	18	LCROSS: Twitter, Facebook, Analog
	19	Facebook, the Morning After, Digital (3 files)
	20	Facebook, the Morning After, Analog
	21	Reactions to Final Tweet, Digital (21 files)
	22	Reactions to Final Tweet, Analog
	23	Swingby, Digital (3 files)
	24	Swingby, Analog

Series III: Awards, Memorabilia, and Ephemera

Box	Folder	Folder Title
1	25	NASA Ames Honor Award to the LCROSS Project Team, 2009
	26	NASA Group Achievement Award to the LCROSS Project Team, 2009
	27	NASA Group Achievement Award to the LCROSS Navigation and Trajectory Design Team, 2010
	28	NASA Systems Engineering Excellence Award, 2010
	29	National Space Society Space Pioneer Award for Science and Engineering, 2010
	30	Popular Mechanics Breakthrough Award, 2010
	31	Space Foundation John L. "Jack" Swigert Jr. Award for Space Exploration, 2010
	32	Book, "LCROSS Memories"
	33	"Craterade" LCROSS Impact Ale
	34	Ephemera
	35	"Git-R-Done" Baseball Cap
	36	Mission Patches and Pins
	37	Oversized Material, LCROSS Posters, Banners, and Team Photograph
	38	Rocket Piñata

Series IV: Miscellaneous Material Accumulated by LCROSS Team Members

Box	Folder	Folder Title
1	39	LCROSS Separation and Impact Event Operations Video, Digital (1 file)
	40	Mission-related Snapshots, Images, and Personal Facebook Pages, Digital (86 files)
	41	Mission-related Snapshots, Images, and Personal Facebook Pages, Analog
	42	Spacevidcast shows related to LCROSS, Digital (2 files)
2	1	LRO/LCROSS Launch Console Handbook (1 of 3)*
	2	LRO/LCROSS Launch Console Handbook (2 of 3)*
	3	LRO/LCROSS Launch Console Handbook (3 of 3)*

*Export-controlled and proprietary information